

This invention relates generally to display devices and more particularly, to a display structure comprising multi-layered images and a method of extracting depth from two dimensional video data to display on such a device.

Conventional display devices present images on a two dimensional screen. Common displays are cathode ray tubes (CRTs), liquid crystal displays (LCDs), Field Effect Displays (FEDs), and projection displays, among others. Various attempts have been made to incorporate the illusion of depth on two dimensional displays. These methods achieve the illusion of depth by presenting separate images to each eye of the viewer.

The main methods of achieving the illusion of depth have been stereoscopic and auto-stereoscopic displays.

20 Stereoscopic displays generally use composite images which are split into two images by glasses worn by the viewer. Each eye piece in the glasses will allow certain characteristic light patterns through to each individual eye. Popular methods of achieving this are through the use of polarisation, shutter glasses, defraction grating, multi colour lens, and dual screen head mounted displays.

Auto-stereoscopic displays do not use glasses but instead generally use a lens configuration in which stereo images on a screen are aligned through lens or optical grating to focus in the general area of the viewers' individual eyes.

One main problem associated with these displays reside in the inability to gain convergence of stereo images to match the distance between the viewers' eyes. Incorrect convergence leads to disorientation and possible nausea when viewed for extended periods. In the case of most auto-stereoscopic displays the viewing area is limited to the focal length of the lens used. This limits the number of simultaneous viewers of a single screen. Traditional auto stereoscopic displays are limited to one or two simultaneous viewers. While, traditional stereoscopic displays require all users to wear glasses. In addition each of these methods require head tracking devices to be incorporated in order to achieve motion parallax.

Certain designs have been made that use multiple levels of images.(US Patent 4,736,214) These designs incorporate reflected images from single or multiple sources. The reflected images of these designs produce "ghostly" multi layered images, which are generally unacceptable for normal lighting conditions.

Images transmitted to these display devices via antenna, VCR, cable etc. are generally compressed during transmission. It is common for these compression algorithms to compress based on pixel change between consecutive frames.

It is an object of the present invention to address the foregoing problems or at least to provide the public with a useful choice.

Further aspects and advantages of the present invention will become apparent from the ensuing description which is given by way of example only.

It is the purpose of this invention to specify a display which improves upon the limitations of display devices mentioned above, while incorporating actual depth.

The preferred embodiment of this invention creates an improved display device incorporating depth, by combining multi-layers of selectively transparent screens to create true depth while incorporating common compression algorithms to extract images into separate channels to be displayed on each screen of the multi-layered display. Implementation of multiple techniques have been used to achieve this end, which solve many problems exhibited in the prior art.

Reference throughout this specification will now be made to the present invention as utilising LCDs for each screen layer. However, it should be appreciated by those skilled in the art that other types of screens that can selectively show an image and selectively become transparent may be used in conjunction with the invention, not necessarily being LCDs.

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Images displayed on the screen furthest from the viewer (background screen) will appear at some depth behind images displayed on the screen closest to the viewer (foreground screen). The transparent portions of the foreground screen will allow  
5 viewers to see images displayed on the background screen.

This arrangement of layering multiple screens allows images to be presented at multiple levels giving the viewer true depth without use of glasses or lens. It also allows for motion parallax without head tracking devices.

10 Additional layers may be added to give greater depth to the display.

In addition a refractor may be placed between the screens to increase viewing angle. This refraction layer bends light such that viewing angle is increased to the full size of a screen placed in front of the refractor. The refractor may be a parallel sheet of optically  
15 clear material or any other type of lens including fresnel lens.

If the foreground screen device chosen requires a polarised light source to display an image then that polarised light source may emanate from a background screen. This is accomplished by placing a polarisation sheet in front of a non-polarised screen or using a  
20 polarised light output display such as an LCD as the background screen.

Polarised light emanating from a background screen allows a foreground screen of LCD structure to remove its rear polariser while still displaying an image. This is due to the fact that the  
25 background screen provides the polarised light necessary to produce a viewable image on the foreground screen.

Removing the number of polarisers in an LCD configuration has the advantage of reducing the number of components and increasing the brightness of the display.

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In a two layer display using separate sources the background may be transmitted as a signal and the foreground transmitted as a second signal to their respective screen. For example, the background image may be of a mountain and the foreground image of a car passing in front of the mountain.

Single source depth extraction may be performed using conventional compression algorithms used in transmission of video data. Prior Art video compression algorithms commonly utilise pixel change between consecutive frames in order to reduce the bandwidth of the data transmitted. This data on pixel change taken from the video compression algorithm can be used to extract depth based on the amount of change each pixel undergoes.

For example, a standard video may be made of a car passing a mountain. The camera is fixed such that the car passes the field of view while the mountain remains still in the frame.

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It should be understood that portions of this summary devoted to polarisation are not limited to LCD structures as it can be easily understood by those skilled in the art that other non polarised displays may be adapted to incorporate certain polarisation characteristics if so desired.

Further more, it is easily understood by those skilled in the art that the above summary covers the use of all screen types not only LCDs. The only requirement for the screen type is an ability to be transparent. As such it should be understood to cover, but is not limited to Projection, CRT, FED and LCD screens.

#### **BRIEF DESCRIPTION OF DRAWINGS**

Further aspects of the present invention will become apparent from the following description which is given by way of example only and with reference to the accompanying drawings in which:

- 15    **Figure 1**    is a diagrammatic view of a basic multi-layered display in accordance with one embodiment of the present invention.
- 20    **Figure 2**    illustrates a multi-layered screen with a refractor in accordance with one embodiment of the present invention.
- Figure 3**    illustrates the moiré interference pattern in multi-layered displays in accordance with one embodiment of the present invention.
- 25    **Figure 4**    illustrates a diffuser and its effect on the moiré interference pattern in accordance with one embodiment of the present invention.

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Figure 7

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### BEST MODES FOR CARRYING OUT THE INVENTION

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The addition of a refractor placed between screens is represented in Figure 2. Light 7 transmitted to the viewer 8 is bent to 9 at refraction angle 10 of the material such that the edge of the rear screen is not seen from any angle of view. Without the refraction of light the edge of the rear screen would be clearly seen 11 from any angle less than 90 degrees.

For minimum distortion a sheet of parallel optically clear material such as glass or acrylic may be used as a refractor 12. Such a refractor would restrict the front screen 3 to being of a smaller size than the background screen 1. In a preferred embodiment of the present invention the foreground screen size would have its edge no less than 135 degrees from the edge of the rear screen.

In another preferred embodiment the refractor may be a lens including but not limited to fresnel. In this embodiment the screens may be of similar size.

The addition of a slightly diffuse layer 13 placed between screens is shown in Figure 4. Without this layer, interference 14 is created by the combination of slightly different pixel patterns of subsequent screen layers. Placing the diffusion layer 13 between screens slightly diffuses the pixel pattern in each screen eliminating interference 15.

Alternately interference can be eliminated by using a stripe pixel pattern on one screen and a 45 degree diagonal pixel pattern on another.

For further clarification a complete assemble is shown in Figure 5. This combination produces a display with a finite true depth defined by the distance between screens 3, 6. It also creates an infinite depth illusion with the addition of a selective diffuser.

- A polariser sheet 17 is placed at the front of the rear screen 1. This creates a polarised light source. Alternately the rear screen could also be an LCD with a polarised output. In front of the polariser is placed a selective diffuser 18. In front of the diffuser is a refractor 8. In front of the refractor is placed a LCD without a rear polariser 16.

When the selective diffuser is set to transparent, the rear screen outputs polarised light to allow an image on the foreground screen to be visible.

- 10 When the selective diffuser is set to diffuse, the rear screen polarised light output is converted to diffuse light, which renders the foreground image invisible.

- With certain screen technologies such as LCD it is desirable to have the ability to render the foreground screen opaque. This preferred embodiment is represented in Figure 6. This combination produces a display in which the foreground screen is rendered opaque. In this configuration the rear screen 1 is followed by a refractor 12 which is followed by a selective diffuser 18 which in turn is followed by the foreground screen 3. To make images on the foreground screen opaque the selective diffuser is selected to diffuse the area behind the area selected to be opaque.

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25 In yet another embodiment of the present invention Figure 6 represents a Tri-layer display incorporating most of the previously mentioned techniques. This display provides three finite depth planes with the foremost screen 19 being selectively opaque due to the selective diffuser 18 placed behind it. The middle LCD screen 16 would have infinite depth due to its lack of rear polariser and the ability of the selective diffuser 18 in front of the rear polariser 17 to diffuse polarised light required for its operation.

Alternatively the separate video signal can be extracted from a single image using data produced by most common video compression algorithms. For example a video signal is transmitted of a car passing in front of a mountain 21, creates a sequence of frames 22. This sequence is fed through a video compression algorithm 23 which converts the image to a sequence of numbers representing pixel properties such as pixel colour, pixel location and amount of pixel motion between consecutive frames.

15 In this example, pixels with a change value above a threshold of X via path 24 to the foreground screen while pixels with a change value below X are sent via path 25 to the background screen. In the present implementation (Figure 8) pixels representing the car have a high value for pixel change and will be directed to the foreground screen and the mountain having a pixel change value of less than X will be directed to the background screen.

20 It can be easily understood by those skilled in the art that the threshold value and tolerance of this value may be adjusted to gain a variety of outputs. In addition multiple threshold values may be defined in multi-layered displays with over two layers.

Thus, it can be seen from the foregoing detailed description and  
25 attached drawings that the present invention includes methods of  
displaying depth in a display allowing for motion parallax, true  
convergence, and wide angle of view without the viewing  
restrictions of prior art displays.

It can also be appreciated that taken individually each component enhances the depth of the display but may also operate independently and in combination to enhance traditional displays. It is obvious to someone skilled in the art that the following claims  
5 may be combined in various manners.

Aspects of the present invention have been described by way of example only and it should be appreciated that modifications and additions may be made thereto without departing from the scope thereof.